



Comparison of effect of transcranial direct current stimulation with cognitive behavioral intervention on craving and resilience of volunteers for quitting addiction

Atefe Khodabande¹, Zohreh Latifi²

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1. Department of Psychology, Khomeinshahr Branch, Islamic Azad University, Khomeinshahr/ Isfahan, Iran

2. **Correspondence to:** Department of Psychology, Payame Noor University, Tehran, Iran

Email: z_yalatifi@yahoo.com

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Abstract

The importance of the craving experiences for the persistence of addiction has been acknowledged in many studies. The purpose of this study was to compare the effect of transcranial direct current stimulation with cognitive behavioral intervention on reducing craving and increasing the level of resilience of volunteers for quitting addiction. The population were comprised of all addicts referring to addiction clinics in. In order to implement the research, 45 participants were selected purposely from the clinic based on the inclusion and exclusion criteria and randomly assigned to three groups (15 participants in each group). The experimental group 1 received electrical stimulation of the brain from the skull twice a week for the 10 sequential sessions. Experimental group 2 received 10 sessions of cognitive behavioral intervention. Research tools were drugs craving questionnaire and the resilience questionnaire. The results of covariance multi-factor analysis of variance showed that trans cranial direct current stimulation and cognitive-behavioral intervention has decreased craving and has increased resilience. Transcranial direct current stimulation and cognitive behavioral intervention can be utilized to enhance resilience and decrease craving in volunteers for quitting addiction referring to addiction clinics.

Keywords: Addicts, Craving, Cognitive Behavioral Therapy, Transcranial Direct Current Stimulation, Resilience

Introduction

Unfortunately, addiction and drug use as a social dilemma are on the rise, particularly among younger generations. [1] The main feature of drug use disorders is a set of cognitive, behavioral and physiological symptoms that show that the person, despite the problems associated with the substance, continues to substance use [2]. Also, the change in brain circuits is an important feature of drug use disorders, which may

continue after detoxification, especially in people with severe disorders. The behavioral effects of these brain changes may be manifested in frequent lapses and intense urge to drug use when people are exposed to drug related stimuli. These continuous effects may be improved by long-term therapies [3]. In the most recent conceptualizations of drug abuse, craving is seen as a central element

that causes persistent and increased use of drugs and dependence to it [4,5]. In the process of treatment, after achieving abstinence, a strong desire to re-experience the effects of the substance is seen [6,7]. The importance of the craving experiences for the persistence of addiction has been acknowledged in many studies [8]. Craving can be defined as a conscious experience and intense and persistent desire to consume drugs [9,10]. However, other theorists oppose this notion, and consider the unconscious motivational dimensions of obtaining and consumption behaviors as dimensions of craving [11]. Also some define craving as "urge to substance use" [12]. Craving plays an important role in the post-treatment relapse phenomenon and consumption and dependence to drugs. This feeling may be seen a few hours after the beginning of the treatment to days and months after its end. The frequency and intensity of cravings slowly diminishes but rarely disappears [13]. Diagnosis and treatment of this clinical manifestation of craving are commonly considered as one of the main factors of treatment outcomes.

Recent studies suggest that resilience is one of the factors that has a protective effect on craving [14]. Resilience is defined as the ability or the consequence of successful adaptation to threatening conditions. Resilience is not merely a passive resistance to harms or threatening conditions, but also involves active participation and proactivity in regard to the environment. This construct is one of the factors preventing the occurrence of psychological problems among people which help buffer them against the psychological effects of problematic events such as addiction [15]. Resilience is one of the important components of psychological capital in relation to addiction, therefore due to the protective effect of resilience in the treatment of addiction and negative consequences of craving it seems necessary to implement interventions to increase resilience and reduce craving [16]. One of the recommended treatments that has been proposed to accelerate the treatment of drug addiction and craving is the Transcranial Direct Current Stimulation (TDCS) device

[17]. In this method, a strong electrical current generates magnetic fields after passing through an electrode implanted in the brain that leads to a milder electrical current in the cortex and thus stimulates the potential for action in the stimulated nerve tissue. Although the mechanism of action of this method is not well understood, the evidence suggests that the probable changes resulting from prefrontal magnetic stimulation may be due to effects on neurotransmitters and nerve cell restorations (regenerations) [18]. The effect of frequent prefrontal cortex magnetic stimulation on dopaminergic neurotransmitters and cortical irritability has been described as a tool for the study and treatment of addiction [19].

In this regard, studies have shown that intervention with this device has been effective in reducing the craving for various drugs, including crack [20], cocaine [21], industrial alcohol [22,23], cigarettes and tobacco [24], binge eating [25] methamphetamine [26], some studies also suggest that neurofeedback, and especially direct prefrontal cortex brain electrical stimulation can reduce craving in substance abusers [27,28].

On the other hand, people who consume drugs are more likely to experience psychological problems. Attention to psychological dimensions during treatment is important in preventing the relapse, the attrition of patients from treatment, the enhancement of the level of post-quitting tolerance and the improvement of psychological symptoms of addicts. Cognitive-behavioral therapy emphasizes recognition of the effects of beliefs, or maladaptive or inefficient attitudes. Studies have reported the effect of cognitive-behavioral therapy on reducing the craving in drug-dependent men and increasing their resilience [29]. Considering that at the present time, decreasing of appetite is the first important factor in preventing relapse and the influential role of psychological symptoms in the desire for substance which are a great challenge for methadone maintenance treatment and other treatments and usefulness and advantages of brain stimulation technologies in the treatment

of addiction (small and portable device, no need for complex computer settings, no need to preparing the patients long hours before initiating the stimulation) on one hand and, and given the fact that no study was conducted to compare the effect of the brain electrical stimulation device (TDCS) on the craving of drug addicts who volunteered to quit addiction with psychological interventions of cognitive behavioral intervention on the other hand, this research was designed to answer the question of whether the application of the TDCS is effective in reducing craving and increasing the level of resilience of addicts who volunteered for quitting, and is it different from cognitive-behavioral intervention?

Method

This research is the quasi-experimental with three groups (two experimental and one control). The statistical population of this study consists of all addicts who had previous heroin consumptions with methadone syrup use between 6 months and one year who were volunteered for addiction quitting in the addiction treatment clinic in Najaf Abad city (Isfahan province, Iran) in the first half of the year 2016. Since in the quasi-experimental designs for comparison of the three groups a minimum sample size of 45 is required [30], 45 people willing to participate in the study were selected based on the criteria for inclusion and exclusion and were randomly assigned to two experimental and one control groups (15 in each group). By coordinating with addiction treatment clinics in Najafabad city, volunteer addicts referring to therapeutic centers to receive psychological services were invited to participate in the study by attending Shahin Mehr center. Inclusion criteria were as follows: methadone intake, lack of psychiatric and personality disorders, lack of simultaneous psychological or drug therapies, age of 25-55. Exclusion criteria were: lack of cooperation and failure to perform assignments provided at sessions, having acute or chronic mental disorders with the diagnosis of the psychologist of the center, taking psychiatric drugs and having physical illnesses.

After sampling from the target population and assigning the sample into two experimental and one control group and receiving the informed consent of the participants. Brain Electrical Stimulation from the skull was administered on the experimental group 1, twice a week for the 10 sessions (anode electrode on the dorsal lateral region of the left prefrontal cortex and cathode electrode on the dorsal lateral region of the right prefrontal cortex and 2 mA of direct electrical current for 20 minutes) with inotophoresis activadose device made by Tek Activa. The experimental group 2 received cognitive-behavioral intervention for 10 sessions (creating motivation to change the process of drugs intake and identifying triggers, coping with negative thinking and cognitive restructuring by teaching A-B-C approach, functional analysis of seemingly unrelated decisions, anger management, tension management strategies to reduce arousal, increasing enjoyable activities, problem solving, supportive networks development). The current source of this device is a 7-volt battery, a maximum current of 4 mA and a maximum voltage of 82 V in form of DC. Methadone syrup intake was between 15 and 20 cc at the start of the intervention that was decreased to below 5 cc during the intervention sessions. Then the patients were entered into the detoxification process with Buprenorphine pills.

The observed ethical considerations during the implementation of the research were that participants should be consciously inclined to participate in the research; the confidentiality of the participants' information was guaranteed; the researcher respected the participants during the research project and refrained from discrimination, conducting treatment sessions for the control group free of charge after completing the sessions.

The following tools were utilized in this study to carry out the measurement steps:

- 1) A 20-item drugs craving questionnaire, is used to measure thoughts and fantasies related to the substance and the temptation of consumption. The questionnaire is scored on a

6-point Likert scale (completely true= 5 to not at all true= 0). The reliability of the questionnaire has been reported 0.94 based on Cronbach's alpha. Anis and Graham's Situational Confidence Questionnaire, ($p= 0.001$, $r= 0.53$), Positive and Negative Emotions and psychological craving were used to assess the validity of the questionnaire which the magnitude and direction of the correlations supported its validity [31]. In the present study, internal consistency based on Cronbach's alpha was 0.90 for the total scale for methamphetamine users.

2) Conner-Davidson Resilience Questionnaire: This questionnaire is able to distinguish resilient from non-resilient people in clinical and non-clinical groups and is used in clinical and research settings. The questionnaire consists of

25 statements that are scored on a Likert scale (0-4), the maximum score for the entire scale is 100. Scores are found by adding the item score for all the items and the resilience score of each respondent is equal to the raw score (the score obtained) divided by 100, multiplied by 100.

Reliability coefficient by using Cronbach's alpha method was 89%, and the validity based on factor analysis was 87%, Mohammadi has adapted it for use in Iran [31]. In this study, Cronbach's alpha for the whole scale was 0.89. Pretest was performed at the beginning of the intervention while posttest was performed after the completion of treatment sessions. The summary of the treatment sessions is presented in Table 1:

Table 1 Summary of cognitive-behavioral temptations intervention sessions

Session	Content
First session	Individual motivational feedback, providing a table for deciding whether or not to continue drug use, the disadvantages of continuous use of substances and the no- change condition, the benefits of exerting changes in substance use, the benefits of continuous use of substances and no-change condition, the disadvantages of exerting changes in substance consumption, determining high risk situations, practical design for high-risk situations.
Second session	Determining the factors leading to substance abuse, planning methods to deal with the cravings and desire for substance use, thought stopping, balancing decision making exercise, delaying.
Third session	Coping with negative thinking, the relationship between thinking and affection, the determination of negative thinking patterns, fighting against negative thoughts and cognitive restructuring, seemingly unrelated decisions, informing persons to high-risk situations, thought functional analysis during risk thinking.
Fourth session	Planning and prediction of emergencies, the occurrence of unexpected triggers or high-risk situations, "if ... so ..." action plans, the hierarchy of coping strategies.
Fifth session	Teaching refusal skills to deal with direct proposals for drug use; the principle of "no thanks", designing of personal refusal sheets, role playing to practice assertive responses.
Sixth session	Criticizing and being criticized, assertive response to criticism, offering critical recommendations with assertiveness, tension management skills, role playing.
Seventh session	Anger and drug use management, determination of anger symptoms, tension management skills, cognitive restructuring in regard to anger triggering thoughts, problem solving in anger related narrations, role playing.
Eighth session:	The pleasurable and enjoyable activities and consumption of substances, investigation of quitting pleasurable activities as a result of the substance abuse, the identification of pleasurable activities as a proper and healthy solution, planning for enjoyable activities, making a commitment for the pre-planned pleasurable events.
Ninth session	Labeling and drug-related problems, problem solving skills, problem definition, possible solutions, choosing a solution, applying that solution, evaluating the selected solution, providing practical examples at the session.
Tenth session	Creating friendships that do not revolve around substance use, cutting relationships with friends and relatives who are harmful, cutting the relationship with drug dealers and consumers, and finding a group of supporters and self-help groups to free oneself from addiction

To analyze the data, multivariate covariance analysis was used with SPSS-24.

Results

The mean and standard deviation of the

age of the experimental cognitive behavioral intervention group participants were 36.40 ± 4.28 years respectively, the mean and standard deviation of the brain electrical stimulation experimental group was 33.40 ± 3.6 , and the mean and standard deviation of the age of the control group was 33.66 ± 3.75 years. 60% of the cognitive behavioral group and 46.7% of the brain electrical stimulation group had diploma, 26.7% of the cognitive behavioral group and 33.3% of the brain electrical stimulation group had associate degree and 13.3% of the cognitive-behavioral group and 20% of the brain electrical stimulation group had bachelor's degree. 13.3% of the cognitive behavioral intervention

of temptation group and 13.3% of the brain electrical stimulation group were single and 86.7% of the cognitive behavioral group were married and 86.7% of the brain electrical stimulation group were married. In terms of financial conditions, most of the participants belonged to middle-income groups and all of them had non-governmental occupations. 30% of the participants had no history of relapse, 20% had one relapse, and 36.66% had two relapses and 3.13% of people had three relapses. The mean and standard deviation of the pretest and posttest scores of the craving and resilience scales for the two groups of experimental and control are presented in Table 2.

Table 2 Comparison of the mean and standard deviation of the pre and posttest scores of research variables

Variables	Source	Cognitive-behavioral intervention		Transcranial Direct Current Stimulation device (TDCS)		Control group	
		Mean	SD	Mean	SD	Mean	SD
Craving	Pretest	66.40	4.23	68.06	2.81	68.40	5.30
	Posttest	46.13	6.02	24.20	3.48	66.73	3.97
Resilience	Pretest	26.26	8.44	29.80	7.63	29.93	4.31
	Posttest	46.13	6.50	36.022	3.48	27.46	8.45

According to Table 2, there is no significant difference between the experimental and control groups in the pretest; however, the craving scores have decreased and the resilience scores have increased in the posttest. To test the normal distribution of pretest and posttest, the Kolmogorov-Smirnov test was used.

The results of this test indicated that *p* values in the Kolmogorov and Smirnov tests are greater than 0.05. Therefore, the distribution of data is consistent with normal distribution. Also, according to the Levine test, the homogeneity between the covariate and dependent groups

was confirmed and all of these paired groups have homogeneity with each other.

Multivariate analysis of covariance was used to evaluate the effect of the TDCS device and comparing it with cognitive behavioral intervention to reduce craving and increase the resilience of addicts under the treatment of addiction in treatment clinics in Najafabad city. The values of the Wilkes Lambda test are given in Table 3. Values range from 0 to 1, with values close to 0 showing a significant difference between the score means of the groups.

Table 3 Wilkes Lambda test to examine the difference between score means of resilience and craving

Source	Value	F	df	Sig	Eta	Statistical power
Between group	0.02	706.73	2	0.01	0.98	1.00
Within-group	0.03	274.25	4	0.01	0.97	1.00
Interaction effect	0.03	268.25	4	0.01	0.97	1.00

As presented in Table 3, the values of 0.02, 0.03 and 0.03 for inter-group, intra-group and interactive effects of TDCS device respectively and comparison with cognitive behavioral intervention on decreasing craving

and increasing resilience of addicts under treatment showed that this interventional effect is at least effective on one of the scales of craving and resilience.

In the following, the results of the intergroup

and intra-group analysis of covariance for the effect of the brain electrical stimulation device

on reducing the craving and increasing the resilience are shown in Table 4.

Table 4 Between participants and within subjects' analysis of covariance with two levels of measurement (pretest and posttest) for craving and resilience

Scale		Source	Sum of squares	df	Squares mean	F	Sig.	Etta	Stat. power
Resilience	Within-group	Factor	10435.28	1.12	9240.85	203.69	0.01	0.87	1.00
		Interaction effect	11621.60	1.12	10291.38	226.85	0.01	0.89	1.00
		Error.	1434.44	31.61	45.36				
	Between-group	Group	8073.60	1	8073.60	269.76	0.01	0.90	1.00
		Error.	838.00	28	838.00				
Craving	Within-group	factor	10143.75	1.32	7684.08	750.41	0.01	0.97	1.00
		Interaction effect	9749.75	1.32	6931.11	676.88	0.01	0.96	1.00
		Error.	378.48	36.96	10.24				
	Between-group	Group	7437.06	1	7437.06	1161.61	0.01	0.96	1.00
		Error.	179.26	28	6.40				

According to Table 4 and the significance of the factors within the groups, there exists a significant difference between the measurement steps for the craving and resilience scales at the $p < 0.01$ level. Also, given to the significance of the group source among the groups, there is a significant

difference between the experimental group and the control group for the craving and resilience scales at the $p < 0.01$ level. The results of the Bonferroni test are presented in Table 5 for pairwise comparison of experimental and control groups in the variables of craving and resilience.

Table 5 Bonferroni test results for pairwise comparison between the experimental and control groups in the variables of craving and resilience.

Variable	Test	Criterion group	Comparison group	Means diff.	Standard error	sig.
Craving	Posttest	Brain Electrical Stimulation	Control group	-42.470	1.685	0.001
		Brain Electrical Stimulation	Temptation cognitive behavioral intervention	-22.248	1.707	0.001
		Temptation cognitive behavioral intervention	Control group	-20.223	1.717	0.001
Resilience	Posttest	Brain Electrical Stimulation	Control group	21.473	10.474	0.001
		Brain Electrical Stimulation	Temptation cognitive behavioral intervention	42.382	5.846	0.001
		Temptation cognitive behavioral intervention	Control group	51.392	5.563	0.001

According to Table 5, there is a difference in the efficacy of the TDCS and cognitive behavioral intervention of temptation on craving of methadone consumers referring to addiction treatment clinics ($p < 0.001$). In other words, the TDCS has been more successful in reducing craving than cognitive behavioral intervention

of temptation. On the other side, cognitive-behavioral intervention of temptation has been more successful in increasing the resilience than the TDCS.

Discussion

The purpose of this study is to compare the

effect of the TDCS with cognitive behavioral intervention of temptation on the craving and resilience of volunteers for quitting addiction who referred to addiction clinics in Najafabad city in 2016.

Based on the results of the TDCS intervention and cognitive behavioral intervention of temptation have influenced craving in volunteers for quitting addiction (methadone consumers). Additionally there is a difference between the effects of the TDCS and the cognitive behavioral intervention of temptation on reducing the craving in methadone consumers, while the TDCS was more successful in reducing craving than cognitive behavioral intervention of temptation.

Since the difference between the effect of the TDCS and cognitive behavioral intervention of temptation on the craving of drug addicts has not been investigated to our knowledge, as a result, it is not possible to compare the findings of this study with other studies. But in regard to effect of the TDCS and cognitive behavioral intervention of temptation on craving of drug addicts, this section is consistent with the results of multiple studies [20-29]. Therefore, based on this evidence, it is assumed that an increase in the activity of either the right prefrontal or the left prefrontal region can lead to a decrease in craving. The prefrontal region, dorsal/lateral is one of the important areas of the prefrontal cortex which is responsible for distinguishing and assessing the behaviors and evaluating consequences of current behaviors and predicting consequences and social control.

A possible explanation for this fact that the stimulation of this area leads to a reduction in craving for narcotics and oral drugs, is that electrical stimulation of the brain by stimulating dopaminergic pathways increases social control, or in other words, increases the ability of methadone consumers in suppressing their urges. Also, the results showed that the TDCS was effective on resilience of volunteers for quitting addiction (methadone consumers) referring to addiction clinics and leads to increased resilience of them.

Since the effect of the TDCS on the resilience of drug addicts has not been investigated to our

knowledge, it is not possible to compare the findings of this study with other studies.

In explaining the findings of the present study indicating the greater effect of cognitive behavioral intervention of temptation than the TDCS, it should be stated that the mechanism of cognitive-behavioral intervention of temptation on resilience through identification the disadvantages of inefficient thoughts and introducing high risk situations during the first and second sessions and the training of coping with the desire to use in the third and fourth sessions, leads to stop thinking and balance in decision making in the times of craving.

With anger management training and tension management strategies, problem-solving skills and enhancement of enjoyable activities, decreasing rumination and mitigating anger's triggering thoughts and applying a problem-solving approach to cope with stressful situations in cognitive behavioral intervention of temptation, the anxiety of drug addicts who consume methadone decreases and this leads to increased resilience.

In order to increase resilience, a comprehensive psychological intervention is needed to provide opportunities for training and practice which can be similar to cognitive-behavioral intervention of temptation.

The effect of the TDCS on resilience seems to be due to decreased craving and consumption motivation. In other words, a person who has less motivation and craving for drug use will be more tolerant of non-consumption and thus is more resistant to stressful situations, which explains the more successful outcomes of cognitive-behavioral intervention of temptation.

As theoretical explanation of the findings, it's noteworthy that stimulation of the posterior-lateral cortex by using direct electrical current is associated with positive emotional change in mood, and the anode stimulation of the left lateral prefrontal cortex brings about the promotion of tasks across a number of cognitive-behavioral tasks and the exploitation of higher levels of cognitive functioning.

Also, the stimulation of this area by stimulating

dopaminergic pathways reduces craving and increases the ability of methadone consumers to suppress their urges, which leads to increased resilience. Because in different situations, choosing an intervention is important in terms of time and cost efficiency, If the main goal is to reduce the craving, use of the TDCS and if the psychological changes including resilience is desired the use of cognitive behavioral intervention of temptation is recommended.

The limitations of this research that raises some problems concerning generalizability of its findings, given the influence of practice effect of pretest training on posttest results caution must be taken in interpretation of the results. Thus, further research on the effect of TDCS on women and with a different population is recommended in order to provide a basis to compare their results with findings of the current study.

However, because of the variety of situations, a time-saving and cost-saving intervention is considered if the primary goal in the treatment process is to reduce craving, use of a TDCS and if mental changes cognitive including resilience is considered Taking cognitive behavioral interventions is recommended.

Conclusion

In general, the findings of this study indicate the effect of TDCS and cognitive behavioral intervention temptation to reduce craving and increase the level of resilience of methadone addicts referred to addiction clinics. According to the results of the TDCS, craving and cognitive-behavioral intervention are more successful at increasing resiliency levels. As a result, considering the location of methadone addicts and considering the treatment goals, these two treatments can be used to improve the psychological status of methadone addicts.

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Authors' contributions

Study Design: AKH, ZL

Data collection and analysis: AKH

Manuscript preparation: AKH, ZL

All authors have read and approved the final version.

Conflict of Interest

"The authors declare that they have no competing interests."

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Availability of data and materials

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